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January 30, 1995

By Hand

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, NW
Washington, DC 20554

Re: ET Docket No. 94-124
RM-8308

Dear Mr. Caton:

On behalf of CellularVision, enclosed please find an original and four (4) copies of its Comments filed in the above-referenced proceeding.

Please direct any questions regarding this matter to the undersigned.

Sincerely,

Michael R. Gardner
Counsel for CellularVision

Enclosures

cc Attached Service List

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
Amendment of Parts 2 and 15 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications	)	ET Docket No. 94-124 RM-8308

COMMENTS OF CELLULARVISION

CellularVision,[1] by its attorneys, hereby files comments in response to the Notice of Proposed Rulemaking ("NPRM") in the above-referenced proceeding. CellularVision's principals are the pioneers of the CellularVision technology for the Local Multipoint Distribution Service ("LMDS"), a revolutionary and competitive video, voice and data service that promises to generate innumerable public interest benefits from the robust use of the largely fallow 27.5-29.5 GHz ("28 GHz") band.

1. The Proposal in the Instant NPRM Regarding the 40.5-42.5 GHz Band Cannot be an Alternative to Licensing LMDS in the 28 GHz Band

The instant NPRM proposes to allocate the 40.5-42.5 GHz ("40 GHz") band for the "Licensed Millimeter Wave Service" ("LMWS"), with similar licensing rules as proposed by the Commission for LMDS in the 28 GHz band. See NPRM, paras. 20-28. CellularVision views this aspect of the instant NPRM with significant skepticism,

[1] CellularVision's affiliated companies include Suite 12 Group, which founded the CellularVision technology for the Local Multipoint Distribution Service in the 27.5-29.5 GHz band and was tentatively awarded a pioneer's preference by the Commission, see Notice of Proposed Rulemaking, Order, Tentative Decision and Order on Reconsideration ("First NPRM"), 8 FCC Rcd 557 (1993), and CellularVision of New York, L.P., which operates a commercial LMDS video service as an alternative to cable television in the New York Primary Metropolitan Statistical Area in the 27.5-28.5 GHz band pursuant to a commercial license granted by the Commission in 1991. See Hye Crest Management, Inc. ("Hye Crest Order"), 6 FCC Rcd 332 (1991).

particularly in view of the fact that the Commission has taken no action in the long-stalled LMDS Rulemaking, CC Docket No. 92-297, since the technical Negotiated Rulemaking concluded in September 1994.[2]

The Commission commenced the instant 40 GHz rulemaking at its October 20, 1994 meeting, with absolutely no suggestion that it was part of a plan to abandon its well-established record in support of licensing LMDS in the 28 GHz band; curiously, the FSS proponents, who steadfastly have refused to consider sharing the unused 28 GHz band with LMDS, immediately seized upon the commencement of the 40 GHz rulemaking to mischaracterize the proceeding publicly as a Commission proposal to move LMDS from the 28 GHz band to the 40 GHz band.[3] In fact, the language of the NPRM says nothing about the Commission abandoning its current proposal in CC Docket No. 92-297 to allocate 2 GHz of spectrum in the 28 GHz band for LMDS.

The fact that the FSS interests would publicly try to speak for LMDS interests

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[2] Due to the technical nature of the LMDS rulemaking, involving issues of co-frequency sharing between LMDS and Fixed Satellite Services ("FSS"), the Commission established a Negotiated Rulemaking Committee ("NRMC") which convened for a 60-day period from July through September 1994 to develop technical rules for the co-frequency sharing of the 28 GHz band. While the NRMC did not achieve a consensus, substantial progress was made. In particular, Suite 12/CellularVision and MSS proponent Motorola Satellite Communications, Inc. developed an LMDS/MSS co-frequency sharing agreement that was endorsed by numerous members of the NRMC. See NRMC 84 (Rev.1), September 23, 1994. In any case, given the present void in the LMDS Rulemaking record regarding the potential public interest benefits of LMDS versus the "paper" FSS systems, CellularVision has argued that the Commission must now provide a window for public comment on those public interest issues, as explicitly set forth by the Commission in its Second Notice of Proposed Rulemaking ("Second NPRM"), 9 FCC Rcd 1394 (1994). See Motion to Proceed, filed by CellularVision in CC Docket No. 92-297, January 26, 1995.

[3] See Patrick Seitz, "FCC Recommends New Ka-Band Rules," Space News, November 14-20, 1994 (copy attached as Appendix 1).

and label their proposal to exile LMDS to the 40 GHz band a "win-win" resolution of the LMDS Rulemaking for FSS and LMDS proponents is preposterous. The FSS interests have not been secretive about their goal to push LMDS to the 40 GHz band, even during the LMDS Negotiated Rulemaking when parties were supposed to negotiate in good faith to develop a solution for co-frequency sharing of the 28 GHz band by LMDS and FSS.[4] Obviously, the FSS interests will "win" if the Commission continues to delay the 28 GHz LMDS Rulemaking, thereby preventing the nationwide deployment of LMDS in the fallow 28 GHz band, while simultaneously hoarding that valuable spectrum for possible FSS use in the future.[5]

Were the Commission to banish LMDS to the 40 GHz band, for numerous reasons discussed in Section 3 below, LMDS would die in its infancy. The result would be a devastating "loss" for potential LMDS system operators and equipment

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[4] For example, Edward Fitzpatrick, Hughes Galaxy Communications, Inc. ("Hughes") Vice President and its representative on the LMDS NRMC, stated to the press during the NRMC, "I'm not anti-LMDS, but there is other spectrum for them." Communications Daily, Vol. 15, No. 151, August 5, 1994, page 7. Likewise, Teledesic Corporation ("Teledesic"), in its application for membership to the NRMC, argued that LMDS should be relocated to a higher band, including the 40 GHz band. See Comments and Application of Teledesic, CC Docket No. 92-297, March 21, 1994.

[5] The only current FSS system operating in the 28 GHz band, NASA's experimental ACTS system, is scheduled to cease operating in 1997. The two "paper" FSS systems of Hughes and Teledesic proposed for the 28 GHz band have yet to be subject to the rigid technical scrutiny of the Commission's public comment process. In fact, the Teledesic system has been hit by skepticism from industry experts and financial analysts, with reactions ranging from "God save us, it's the stupidest damn thing I've ever heard of," to "[i]t ain't gonna work." John J. Keller, "McCaw-Gates Satellite Plan Draws Skeptical Reviews," The Wall Street Journal, March 22, 1994 at B4 (quoting John Pike, director of the Federation of American Scientists' Space Policy Project, and Howard Anderson of the Yankee Group, respectively). If these paper proposals survive technical scrutiny and emerge from the drawing board, they must then satisfy the harsh financial scrutiny of Wall Street, which may refuse to finance these systems' multi-billion dollar price tags. In a best-case scenario, these paper proposals are years away from being operational.

manufacturers, workers in the high-tech industry, the U.S. economy and the U.S. Treasury, which would benefit enormously from LMDS license spectrum auctions of the 28 GHz band, and ultimately, consumers who deserve competitive communications alternatives.[6] Instead of providing a "win-win" solution as the FSS propaganda machine so desperately wants the Commission to believe, the prospect of LMDS in the 40 GHz band represents a graveyard for a promising new service and a transparent attempt by the predatory FSS interests, led by Hughes and Teledesic, to eliminate the immediate competition that LMDS is poised to provide as an affordable broadband lane on the Information Superhighway.

2. The Commission Already Has Rejected Licensing LMDS at 40 GHz

As the Commission has recognized, there is no technical evidence in the record in any proceeding at the Commission that contains any legitimate basis for licensing LMDS at 40 GHz as an alternative to 28 GHz. In fact, the Commission has previously considered and dismissed any suggestion that LMDS could operate in frequency bands

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[6] The Congressional mandate for the Commission to promote competition to cable television is well-settled, Annual Assessment of the Status of Competition in the Market for Delivery of Video Programming, First Report in CS Docket No. 94-48, FCC 94-235, paras. 6-7 (September 28, 1994) (Commission recognizes Congressional policy of "promot[ing] the emergence of effective competition through the entry of alternative distribution technologies"), as is the Commission's consistent findings that LMDS would offer such competition. See Second NPRM, para. 8 ("[T]here appears to be considerable consumer interest in using the [28 GHz spectrum] for video distribution services . . . [and] a new source of competition to franchised cable companies, wireless cable companies and other video service providers would further the public interest"). The fact that the recent launch of Direct Satellite Service ("DSS") has exceeded industry expectations demonstrates the U.S. consumer's desire for cable alternatives, despite the DSS subscriber hardware cost of approximately $1,000, and the inability of DSS, unlike LMDS, to deliver local broadcast channels, provide "video on demand" and two-way interactive communication. In view of the fact that LMDS clearly is a much more affordable, superior consumer technology, and that Hughes is a leader in the DSS industry, Hughes's transparent and anti-competitive efforts to obstruct the deployment of LMDS in the 28 GHz band are not surprising.

above 28 GHz, recognizing that the 31 GHz or 40 GHz bands, for example, are too narrow in bandwidth, not sufficiently contiguous, and not adequately protected to support LMDS, leaving the "28 GHz band the most suitable frequency band available" for LMDS. Hye Crest Order, paras. 11, 21.

The Commission also rejected requests by Hughes and Norris that LMDS should be allocated in the 37 GHz or the 40 GHz bands, stating that "we will not grant further consideration to [these] suggestions since there is no evidence in the record that the beneficial uses we anticipate from point-to-multipoint use of the 28 GHz band are likely to materialize at the higher bands." Second NPRM, n. 15 (emphasis added). The Commission appropriately recognized that by precluding LMDS from immediately using the 28 GHz band, LMDS "either may never become available or may be considerably delayed while another block of spectrum is found and new technologies developed." Id., para. 44.

In the context of this notable void in the record of support for licensing LMDS anywhere but in the 28 GHz band, the only "support" for the FSS-inspired "solution" is in a few simplistic form letters that obviously were solicited recently by the FSS interests in their desperate effort to generate misguided support for their anti-competitive campaign. These boilerplate letters fail to provide any technical support for their position that LMDS should be allocated at 40 GHz in the U.S.

3. LMDS is Not Viable in the 40 GHz Band

Attached as Appendix 2 is a paper prepared by CellularVision's technical consultants entitled "LMDS is Not Viable in the Frequency Bands Above 40 GHz." This paper discusses in detail the numerous technical and economic reasons why LMDS cannot be a viable video, voice and data service in the 40 GHz band in the U.S.

and most parts of the world. This paper also confirms why the European allocation of the 40 GHz band for the proposed Multipoint Video Distribution Service ("MVDS") is irrelevant to the appropriate deployment of LMDS in the 28 GHz band in the U.S. Briefly, the important conclusions of this technical paper are as follows:

A. Since the propagation characteristics of signals in the millimeter wave frequency bands are extremely dependent on climatic conditions, a uniform allocation at 40 GHz and above in all countries is not feasible

Initially, it must be recognized that since propagation characteristics in the millimeter wave frequency bands are radically different depending on climate zone, drastic variations in performance occur from country to country.[7] Accordingly, the FSS interests' claim that the U.S. must be consistent with European countries in licensing LMDS in the 40 GHz band is a red herring. As CellularVision's technical paper reports, in much of the world the degree of rainfall attenuation at 40 GHz will be so severe that it will jeopardize the viability of an LMDS system. Thus, despite the transparent, anti-competitive urging of the FSS interests, a uniform LMDS allocation at 40 GHz worldwide would doom LMDS in most parts of the world, including the U.S.

B. The cost of an LMDS system at 40 GHz is projected to be 30 to 40 times the cost at 28 GHz

Based on differences in signal propagation, component technology and system implementation, CellularVision projects that LMDS system costs at 40 GHz would increase by a factor of 30-40. This astronomical increase in cost is primarily due to the dramatic reduction in the maximum range of an LMDS system at 40 GHz, requiring 7.3 times as many hub transmitters as are required at 28 GHz based solely on line-of-

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[7] See "Spectrum Allocation Considerations," by Bernard B. Bossard, attached as Appendix 3, para. 11.

sight considerations; the approximate doubling in cost of transmission network components; and the doubling of the density of the network due to the inability to serve non-line-of-sight subscribers at 40 GHz. Additional increases in cost due to foliage losses and backscatter interference result in a conservative conclusion that LMDS at 40 GHz would be 30-40 times the cost at 28 GHz.[8] Obviously, such a dramatic increase in cost would render LMDS cost-prohibitive as a broadband delivery service seeking to compete with cable television and other services.

C. European MVDS is not the same as U.S. LMDS, and the operational viability of MVDS systems in the 40 GHz Band in Europe is unproven

Although the 40 GHz band has been available in Europe for MVDS for four years, it is telling that no MVDS systems are operating today. The serious technical and economic disadvantages of MVDS systems in the 40 GHz band were clearly recognized by the U.K.'s MVDS Working Group in November 1993, which viewed European MVDS as a limited capacity (25-30 channels), one-way video service that could not compete with cable. Thus, European MVDS is not U.S. LMDS. Further, in recommending the 40 GHz band for European MVDS in 1990, the CEPT recognized that its assumptions about MVDS system viability were based on a climate in Northern Europe dominated by drizzle; the CEPT further recognized that those assumptions could not be extended to continental and subtropical zones, such as the U.S.[9]

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[8] See LMDS is Not Viable in the Frequency Bands Above 40 GHz, Appendix 2, pages 4-11.

[9] See id., pages 11-16.

D. In addition to the prohibitive cost, LMDS would suffer a degradation in spectral efficiency by a factor of four at 40 GHz, thus requiring four times as much spectrum in order to offer competitive services

A key feature of the LMDS system architecture in the 28 GHz band is its ability to reuse the same frequency in every cell due to a combination of propagation characteristics, equipment performance and system geometry. By contrast, in the 40 GHz band, an LMDS system would not be able to achieve the necessary polarization and sidelobe isolation to achieve 100% frequency reuse. LMDS spectral efficiency would be reduced further by increases in receiver local oscillator stability and phase noise in the 40 GHz band. As a result, LMDS would require four times the spectrum at 40 GHz that is required at 28 GHz.[10]

E. In comparison to terrestrial LMDS, satellite uplinks proposed for the 28 GHz band would suffer no degradation in spectrum efficiency in the 40 GHz band, and the MILSTAR satellite system demonstrates the viability of satellite uplinks in bands above 40 GHz

While LMDS in the 28 GHz band can reuse the spectrum more than 20,000 times on the earth surface, FSS systems proposed for the 28 GHz band are capable of reusing the spectrum only 12 to a few hundred times. As discussed above, while moving LMDS from the 28 GHz band to the 40 GHz band would involve a degradation in spectrum efficiency by a factor of four, the FSS systems proposed for the 28 GHz band would suffer no degradation in spectrum efficiency by operating at 40 GHz.[11]

The propagation effects that impact the 40 GHz band are most severe at low altitudes over the horizontal paths over which LMDS operates. Since FSS systems, however, operate on slant paths which may approach zenith, they are much more

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[10] See id., pages 17-18.

[11] See id., page 19.

likely to be successfully operated in the 40 GHz band than LMDS systems. In fact, the U.S. military EHF satellite system ("MILSTAR"), which is a real system operating with uplinks in the 44 GHz band, has proven the viability of satellite uplinks in the bands above 40 GHz.[12] Accordingly, if the Commission chooses to resolve the LMDS Rulemaking by moving FSS or LMDS to other spectrum, there is no viable alternative for LMDS, while FSS uplinks are ideally suited for the bands above 40 GHz.

4. The Commission Should Not Allocate Spectrum Prematurely Before a Specific and Feasible Use For That Spectrum Has Been Identified and Tested

Finally, in response to the Commission's general proposal to make available 18 GHz of spectrum in the frequency range between 40.5 and 153 GHz, CellularVision believes strongly that the Commission should not prematurely allocate spectrum for a specific type of service until the technical support for a particular service in that spectrum has been demonstrated.[13] To allocate spectrum for services that ultimately may never be deployed would be shortsighted and ill-serve the public, which deserves to receive the benefits of maximum competition from the publicly-owned spectrum.

In the instant case, Chairman Hundt's desire to maximize revenues from spectrum auctions would be frustrated if the Commission were to designate the unusable 40 GHz band for LMDS. Ironically, the FSS proponents, led by Hughes and Teledesic, who refuse to consider co-frequency sharing of the 28 GHz band, apparently do not intend to pay auction prices for spectrum. Accordingly, if LMDS is exiled from the appropriate 28 GHz band, not only will a viable competitor to cable and other services be thwarted, but the U.S. Treasury will be denied billions of dollars

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[12] See id., pages 20-21.

[13] See Spectrum Allocation Considerations, Appendix 3, para. 9.

that would otherwise be generated from LMDS license auctions in the 28 GHz band.

5. Conclusion

CellularVision submits that the Commission's proposed allocation of the 40 GHz band for "LMWS" cannot be used as an alternative to licensing LMDS in the 28 GHz band. In view of the severe technical restrictions that LMDS would face at 40 GHz, and the fact that LMDS' costs would increase by approximately 30-40 times at 40 GHz, LMDS simply would not be a viable service at 40 GHz. The FSS interests' citations to the European allocation of MVDS at 40 GHz as a basis for exiling LMDS to 40 GHz are irrelevant; the Europeans have recognized the severe limitations of MVDS, and it is telling that no one has operated an MVDS system at 40 GHz. If the Commission's solution to the LMDS Rulemaking is to move either LMDS or FSS to other spectrum, it should relocate the paper FSS systems proposed for the 28 GHz band since FSS uplinks can (and currently do) operate successfully above 40 GHz.

Respectfully submitted,

CellularVision

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January 30, 1995

APPENDIX 1

FCC Recommends New Ka-Band Rules

By PATRICK SEITZ
Space News Staff Writer

WASHINGTON — The U.S. Federal Communications Commission (FCC) issued proposed rules Nov. 8 that could remove a major obstacle to the creation of innovative new global broadband satellite services such as Teledesic and Spaceway.

The FCC rules for the allocation of Ka-band radio spectrum could settle a conflict between the proposed satellite systems and planned terrestrial wireless television services.

The rules would resolve the conflict by allocating separate frequency bands for satellite and terrestrial systems. The commission had sought to put both types of services in the same frequency band but an industry panel formed by the FCC in July determined in September that the two would interfere with each other.

Trenholme Griffin, vice president of corporate affairs for Teledesic Corp. of Kirkland, Wash., said the arrangement appears to be a win-win situation for both types of service.

The FCC asked that initial comments from interested parties about the proposed rules be filed by Jan. 30. Final comments are due March 1, 1995.

Ka-band spectrum is expected to be highly sought after because of its availability for new applications. Teledesic, backed by cellular phone pioneer Craig McCaw and computer software entrepreneur Bill Gates, has proposed a $9 billion system using 840 low orbiting satellites to provide high-speed, high-capacity data transmission. Hughes Communications Inc. of Los Angeles plans to launch nine geostationary satellites for its $3.2 billion Spaceway system to provide video telephony and high data rate computer links.

In its proposed rules, the FCC has set aside 2 gigahertz of spectrum in the 28 GHz band for satellite services to fixed locations. This spectrum was allocated worldwide to uplinks for fixed satellite services at the 1971 World Administrative Radio Conference, sponsored by the International Telecommunication Union of Geneva. The band is currently being used by NASA's Advanced Communications Technology Satellite, as well as Japanese and European satellites.

At least two of the proposed global mobile telephone systems using constellations of low Earth orbiting satellites — Motorola's Iridium and TRW's Odyssey — have indicated that they want to use the Ka-band spectrum for feeder links. These links transmit spacecraft control information between Earth stations and the satellites.

The proposed rules also set aside 2 gigahertz of spectrum in the 41 GHz band for wireless multichannel television services, also called Local Multipoint Distribution Services. These services would broadcast 50 channels of programming in metropolitan areas and provide competition to cable and traditional over-the-air television broadcasts.

SPACE NEWS, November 14-20, 1994.

APPENDIX 2

LMDS is Not Viable in the Frequency Bands Above 40 GHz

Prepared by

CellularVision

January 30 ,1995

LMDS is Not Viable in the Frequency Bands Above 40 GHz

INTRODUCTION

The purpose of this paper is to examine some of the issues affecting the viability of Local Multipoint Distribution Service (LMDS) in the frequency bands above 40 GHz. The Commission's current proceeding focused on potential commercial uses of the bands above 40 GHz has resulted in some discussion outside the LMDS community about the potential to operate the LMDS service above 40 GHz instead of in the currently-licensed 28 GHz band. Such discussion has been conducted in ignorance of important facts regarding the potential of LMDS in bands other than the 28 GHz band. This paper outlines those facts and clearly demonstrates that *LMDS is not viable in the frequency bands above 40 GHz in the United States and most other countries.*

This conclusion is based upon three key points, each of which is discussed in detail herein.

- First, operation of the LMDS system above 40 GHz results in a direct increase system cost by a factor of 30 to 40 times. This shocking increase in system cost, which results solely from the differences in propagation, component technology, and system implementation costs between the 28 GHz and 40 GHz bands, renders the attractive LMDS technology unworkable as a business or even a non-profit venture. Another "cost" increase arises from the fact that cable-competitive LMDS will require four times as much spectrum above 40 GHz as is required at 28 GHz.

- Second, although bands above 40 GHz have been authorized for years in Europe for services which, at first glance, are similar to LMDS, there is not a single 40 GHz LMDS-like system operating anywhere in the world today. This is because of the fact that, in spite of the availability of the 40 GHz band for such services, alternatives exist which are far more attractive than 40 GHz given the potential 40 GHz system cost and availability of components. Moreover, the European system is based on a rain rate of 3 to 7 millimeters per hour. This rain rate in the U.S. covers

only about 15 percent of the land mass for desired system availability--hence the European system is unusable in the U.S.

- Third, although the system architecture and geometry of LMDS are highly spectrally efficient at 28 GHz, allowing frequency reuse in every cell, the spectral efficiency potential degrades by a factor of four for LMDS at 40 GHz, while satellite uplinks would suffer no degradation in spectral efficiency by moving from 28 GHz to 40 GHz. This is a consequence of the fundamentally different system architectures for LMDS and satellite systems.

This latter point is instructive: the operation of satellite uplinks for fixed satellite service (FSS) in the frequency bands above 40 GHz is a proven, attractive solution to any co-frequency sharing problem between LMDS and FSS, should the FSS proponents continue to be unwilling to work toward a compromise to accommodate both services in the 28 GHz band. Satellite uplinks above 40 GHz are based on proven, available technology--the very technology for which the Commission is seeking potential commercial applications.

KEY ISSUES

The Commission has committed to consideration of two key issues in examining the potential for the operation of commercial services in the bands above 40 GHz:

(1) the availability of reasonably priced components for implementation of systems;

(2) the nature of radio propagation and its effects on system viability given projected system architectures.

Other factors, such as the location of services in the band with respect to military frequency allocations and avoidance of weapons systems allocations, are independent of the architectures of the commercial services considered, and are of secondary concern.

Below, several issues key to the viable implementation of an LMDS service are examined, and the impact on system viability resulting from hypothetical operation above 40 GHz as opposed to the currently licensed 28 GHz band is demonstrated.

LMDS SERVICE ABOVE 40 GHZ WOULD COST 30 TO 40 TIMES AS MUCH AS 28 GHZ LMDS !

Operation of the LMDS system above 40 GHz results in a direct increase system cost by a factor of thirty to forty (30 to 40). This cost increase for operations in the U.S. is due to differences in propagation, component technology, and system implementation costs between the 28 GHz and 40 GHz bands. Such a cost increase obviously makes LMDS unviable as an broadband service delivery alternative to cable and switched broadband networks. With some estimates of the cost to "wire" the United States with fiber in the $400 million to $ 1 trillion range, it is clear that cost-effective broadband alternatives should be strongly considered. The LMDS opportunity should not be squandered due to an ill-advised frequency allocation in the wrong band. LMDS offers the potential to save much of this projected $400 million to $1 trillion cost to the U.S. economy and offers a service-provider business opportunity for new market entrants that the increasingly monolithic cable, telephone, and satellite companies cannot.

With such a significant cost increase in moving from 28 to 40 GHz, LMDS could not exist as a non-profit venture, let alone a business prospect to provide reasonable return on invested capital. Below, the impact of propagation, system component cost, and other factors are addressed which clearly demonstrate that LMDS is not viable in the bands above 40 GHz.

Beyond the simple issue of cost, operation of the LMDS system above 40 GHz may not be possible at any cost due to the inability to achieve the necessary polarization and sidelobe isolation in the system components to achieve 100 percent frequency reuse in every cell. This issue is addressed in detail elsewhere in this paper. The prospect of operating LMDS in a frequency band above 40 GHz and accepting a less-than-achievable spectrum reuse efficiency is an unthinkable waste of the public spectrum resource. Projections based on available technology indicate that while one GHz of spectrum per LMDS service provider is required at 28 GHz, *four GHz of spectrum will be required per LMDS service provider above 40 GHz.*

LMDS Operation Above 40 GHz Will Require a Minimum of 7 Times As Many Cells

A primary drawback of LMDS operation above 40 GHz is the number of LMDS "cells" required to serve a given area. Both operation of the CellularVision of New York (CVNY) LMDS system (under the only current commercial LMDS license) and detailed

analysis and consideration by the 28 GHz Negotiated Rulemaking Committee have demonstrated the viability of LMDS operations at 28 GHz with three-mile-radius cells. Likewise, systems operating elsewhere in the Americas are successfully exploiting the 28 GHz spectrum for LMDS. On the other hand, as the link budgets in Table 1 demonstrate, LMDS operation above 40 GHz (specifically 41 GHz) has a severe impact on the number of hub stations required for operation--the number of hubs required is so high that the system is rendered economically unviable due to this factor alone. For purposes of evaluation, it has been assumed that the principles of system operation are intended to be the same for the system above 40 GHz as they are at 28 GHz. Indeed, this is necessary to make the comparison valid and to fully bring to light any benefits or penalties which may result due to operation of the LMDS system at 40 GHz.

TABLE 1.
LINK BUDGETS FOR LMDS OPERATION AT 28 AND 41 GHZ
FOR 99.9 % AVAILABILITY

System Parameter	28 GHz System	41 GHz System
Power Transmitter	+ 20 dBW	**+ 16.5 dBW**
7 dB linearity backoff	+13 dBW	+9.5 dBW
50 channel factor (-17 dB)	- 4 dBW / channel	- 7.5 dBW / channel
Transmitter line loss	- 5 dBW / channel	**- 9 dBW / channel**
Transmit antenna gain	+ 7 dBW EIRP / channel	**+ 2 dBW EIRP / channel**
Maximum range	3 miles / 5 km	**1.15 miles / 1.85 km**
Path loss (15 mm/hr rain)	-148.4 dB @ 28 GHz	-138.4 dB @ 41 GHz
Isotropic receive level	- 141.4 dBW / channel	- 136.4 dBW / channel
Receive antenna gain	+32 dBi	**+29 dBi**
Received carrier level	- 109.4 dBW / channel	- 107.4 dBW / channel
Receiver noise figure	6 dB	**8 dB**
Receiver Noise level (18.6 MHz bandwidth)	-125.4 dBW / channel	-123.4 dBW / channel
Carrier to noise ratio	16 dB	16 dB
Video SNR	45 dB	45 dB
Picture "Q" rating	3.8	3.8

Several of the system parameters and their associated values at 41 GHz are highlighted and account for the following conclusion: At 41 GHz, LMDS will require *7.3 times as many hub transmitters* as are required for operation at 28 GHz. Each of the highlighted items in Table 1 represents a key difference between the LMDS systems at 41 GHz and 28 GHz.

40 GHz LMDS Transmission Equipment Cost is Double the 28 GHz Cost

Power Transmitter:

For the power transmitter, currently available 100 Watt TWT amplifiers are assumed at 28 GHz. These devices are currently in use. However, at 41 GHz, the availability of cost-effective power transmitter devices is highly questionable, and the projected available power is 45 Watts -- representing an immediate 3.5 dB implementation penalty associated with operation at 41 GHz as opposed to 28 GHz. Given the availability of 45 Watt tubes, the cost is projected to be nearly double the cost of the widely-available 28 GHz 100 Watt tube.

Transmitter Line Loss:

Due to the difference in frequency, the transmitter line loss is expected to be approximately 0.5 dB greater at 41 GHz than at 28 GHz.

Transmitter Antenna Gain:

The transmitter antenna gain is expected to be degraded by about 1 dB at 41 GHz relative to the achievable gain at 28 GHz. This is a result of two factors: first, while a given physical aperture would be expected to produce higher gain at the higher frequency, the physical aperture must be modified from the existing 28 GHz design to achieve an equivalent elevation beamwidth and sky-oriented sidelobe suppression. This is required to ensure coverage of subscribers both close to and distant from the hub transmitter site. Second, given the same azimuth and elevation coverage, implementation losses, even with an allowance for doubling the cost of the antenna, are projected to result in a one dB penalty.

Receiver Antenna Gain:

As with the transmitter antenna, one could imagine maintaining the same physical aperture size and increasing the gain. In fact, due to operational constraints associated with receiver installation, pointing alignment tolerances and the mechanical stability of the antenna platform (as observed in the commercial LMDS system operating in New York City), the beamwidth of the antenna must be maintained at about 4 degrees. Thus its theoretical gain would be maintained at about 32 dB. Unfortunately, the electrical efficiency of the antenna material will be lower, and the temperature and design sensitivity of the feed network will be higher, resulting in a gain degradation in the range of two to four dB from the 28 GHz design. We have used a value of 3 dB. Additionally, and for the same reasons, sidelobe suppression and cross-polarization isolation will also degrade. These subjects are addressed separately below.

Receiver Noise Figure:

The receiver noise figure degrades by about 2 dB in moving from 28 GHz to 41 GHz. This is a result of the difference in low-noise amplifier design characteristics along with the mixer and image filter characteristics. Even with the 2 dB degradation in system noise figure, the cost of the down converter is expected to be a minimum of 75 percent higher, with a cost increase factor of more than 100 percent likely.

Path Loss / Maximum Range:

The upshot of the design degradation associated with the hypothetical move from 28 to 41 GHz in the U.S. is that the maximum range of the system collapses from 5 kilometers (3 miles) to 1.85 kilometers (1.15 miles). This assumes 99.9 percent availability in Crane rain rate region D2 and a 20 MHz channel spacing in the LMDS system. **Note that this would result in an increase by a factor of $(5/1.85)^2$ or 7.3 in the number of hub transmitters required to serve a given LMDS service area.** The impact of this seven-fold increase in transmitter cost is alone enough to render LMDS service unviable in the bands above 40 GHz, but in addition to the need for more than seven times as many transmitters, each transmitter is expected to cost two times the cost of the 28 GHz transmitter equipment. This is hardly a good indication for the

viability of LMDS in the bands above 40 GHz--there is no way to offer a cost-competitive cable alternative given the cost of LMDS system transmitters alone above 40 GHz !

Other Design Considerations Make 40 GHz LMDS Cost Prohibitive

Beyond the simple issues of propagation differences and component efficiency and availability lurk several other design factors which render LMDS unviable in the bands above 40 GHz. These include achievable receiver figure of merit and cost, the cost of the LMDS "feeder links" to deliver programming material and transport two-way communications traffic to and from the hub transmitters, problems with achieving the necessary sidelobe and cross-polarization performance in the receiver antennas, receiver local oscillator stability, and degradation in the number of subscribers reachable by specular reflections on indirect paths. Additionally, the real estate costs associated with deployment of a much more dense network of transmitters is are likely to have a severe impact on total system cost.

These problems associated with operation of LMDS above 40 GHz demonstrate that the proven 28 GHz LMDS system represents a delicate balance between propagation considerations and practical design limits for cost-effective components which provides a cost-competitive broadband communications alternative for the consumer. Clearly, 40 GHz LMDS would not allow this alternative to reach the marketplace for the benefit of consumers and small business alike.

Receiver Figure of Merit and Cost:

Achievement of a high-volume manufacturable subscriber receiver unit with the figure of merit assumed in the link budget of Table 1, above, will result in a cost increase relative to the 28 GHz receiver of 75 to 100 percent. The expected manufacturing yield will be lower because of the need for tolerances approximately 30 percent tighter than those required for 28 GHz manufacturing. The semiconductor components, transistors and diodes are more expensive and the signal distribution and beam-forming network losses will be higher than for the 28 GHz system.

LMDS Feeder Link Costs:

The seven-fold increase in hub transmitter sites will be accompanied by a minimum seven-fold increase in feeder network components for programming and two-way service distribution. Additionally, an approximate 20 percent increase in the number of feeder relay sites beyond the number of hub stations is expected due to the need to maintain a sufficient carrier-to-noise ratio on the feeder links. Moreover, the costs of the feeder network components is expected to be roughly double the cost of similar components at 28 GHz.

Degradation in System Coverage--Scattering Effects:

Service to subscribers which are not in line-of-sight to an LMDS hub transmitter has been demonstrated in the current commercial 28 GHz LMDS system in New York. The delivery of the LMDS signal to non-line-of-sight subscribers depends upon specular reflection of the LMDS signal from scattering objects with sufficient power in the reflected signal. There are two expected problems associated with service to non-line-of-sight subscribers at 40 GHz: a drastic reduction in specular reflections and a drastic reduction in the power level of the reflected signals. The first effect of moving to the bands above 40 GHz from 28 GHz is the change in the relationship between the absolute surface roughness of reflecting surfaces and the wavelength of the LMDS signal. The wavelength is about 32 percent smaller at 41 GHz than at 28 GHz. This will result in a reduction in specular reflections to serve non-line-of-sight subscribers--diffuse reflections are unusable as a non-line-of-sight reception opportunity. Secondly, in those situations where specular reflections still exist, the attenuation due to the reflection is expected to be 3 to 10 dB higher at 41 GHz than at 28 GHz. The European 41 GHz system is acknowledged to be line-of-sight only.

The combination of these factors significantly decreases the likelihood that subscribers in shadowed areas can be served. If this is the case, two undesirable outcomes may result: potential subscribers in shadowed areas will be denied service and/or the transmission network must be even more dense than the one required solely by consideration of line-of-sight propagation effects. Thus, the number of transmitter hub stations, feeder network components and repeaters *is expected to be double* what would be required if the reflection and scattering behavior of the LMDS signal was the same at 41 GHz as 28 GHz.

Tree and Other Foliage Attenuation:

Compounding the degradation in capacity to serve non-line-of-sight subscribers by specular reflection is the increase in LMDS signal attenuation by trees and other foliage caused by a potential move from 28 to 40 GHz. While no detailed measurements of foliage penetration at 40 GHz are known to exist, existing empirical data (e.g., NTIA Report 89-251) for the 20 to 30 GHz band and the 50 to 60 GHz band show a clear monotonic increase in foliage attenuation both within and between the bands. It is estimated that the foliage losses will increase on a given path by an amount between 3 and 8 dB in moving from 28 GHz to the bands above 40 GHz. This increase alone would eliminate service to a majority of subscribers given the projection that subscriber receivers operating in the presence of foliage blockage must operate within approximately 5 dB of the system threshold in rain. This problem associated with potential LMDS operation at 40 GHz only reinforces the need to double the transmitter network density beyond that required by line of sight considerations.

Rain Backscatter:

An additional propagation issue that will drive the need to increase the density of the hub transmitter network is the increased occurrence of backscatter phenomena associated with rain events on transmission paths above 40 GHz. As wavelength (about 7 millimeters at 41 GHz) approaches the diameter of rain droplets, backscatter increases significantly as a factor in addition to forward-path attenuation. This backscatter component results in a diffuse interference signal incident at receivers in the vicinity of the backscatter surfaces. Given this, the performance, measured by maximum range and interference suppression capacity, of the LMDS system in the bands above 40 GHz is expected to be degraded from the line-of-sight performance projected in Table 1, above. This factor will further drive the need for transmitter networks of greater density.

Real Estate Costs Associated with Transmitter Sites:

A final cost factor resulting from the hypothetical move from 28 GHz to 40 GHz is the cost of real estate associated with the LMDS transmitters--hubs, feeders, and relays. Since the "density" of the transmitter network is expected to be at least 15 times higher (7.3 times 2) at 40 GHz than at 28 GHz, the precise location of the transmitters will be a critical issue. The increased demand for transmitter sites will result directly in higher

per-unit costs for sites. Further, situations will arise where the LMDS service provider is forced into paying exorbitant fees to lease or purchase transmitter sites critical to providing service to specific areas. These two factors will further increase LMDS deployment costs.

40 GHz LMDS Service Cost Increase -- Summary:

Given the need for more than seven times as many hub transmitters at 40 GHz as are required at 28 GHz based on line-of-sight considerations, the projected cost of the transmission network based on component costs of approximately double the 28 GHz cost and the need to again double the density of the network due to sharp differences in ability to serve non-line-of sight subscribers by specular reflection, the cost of LMDS service at 40 GHz is projected to be thirty (30) times the cost at 28 GHz. Additionally, given the additional cost factors associated with foliage losses, backscatter interference and real estate considerations, the cost at 40 GHz is projected at thirty to forty (30 to 40) times the cost at 28 GHz. It should be noted that a cost increase factor of two would be enough to render LMDS unviable at 40 GHz given the revenue margins achievable when competing services are considered. This astounding factor of 30 to 40 clearly indicates that LMDS is not viable in the bands above 40 GHz.

THERE ARE NO LMDS SYSTEMS ABOVE 40 GHZ IN THE WORLD BECAUSE THEY ARE NOT VIABLE ABOVE THE 28 GHZ BAND

Although bands above 40 GHz have been authorized for years in Europe for services which, at first glance, are similar to LMDS, there is not a single multipoint distribution, LMDS-like system operating anywhere in the world today. Apparently, no hardware supply contracts for 40 GHz systems have been awarded in Europe--This is contrasted with the situation in the Americas, where 28 GHz LMDS systems are licensed and operating in North and South America, and the 28 GHz hardware market for LMDS in the Americas is rapidly expanding.

Beyond these illuminating facts, even if 40 GHz systems were deployed in Europe in the future, their planned architecture and specifications would preclude their role as an effective broadband cable competitor, which is the primary goal for LMDS in the U.S. Climate differences between Europe and America would make the 40 GHz system unviable as we have already detailed by examining link budgets and cost impact. Below, some key differences between the European 40 GHz Multipoint Video